



YAKEEN

Lecture - 3

SOLUTIONS



By

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TODAY'S GOAL

RAOULT'S LAW

IDEAL SOLUTION



RAOULT'S LAW

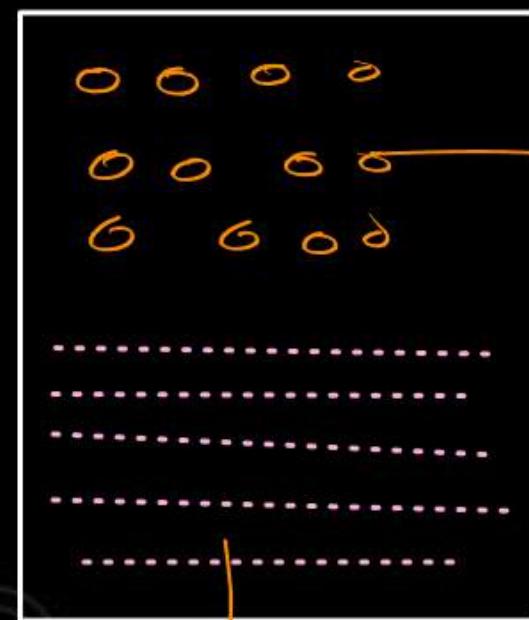


V.P. of any Component in solution
is equal to product of V.P. of that component
in pure form & mole fraction of that component
in solution



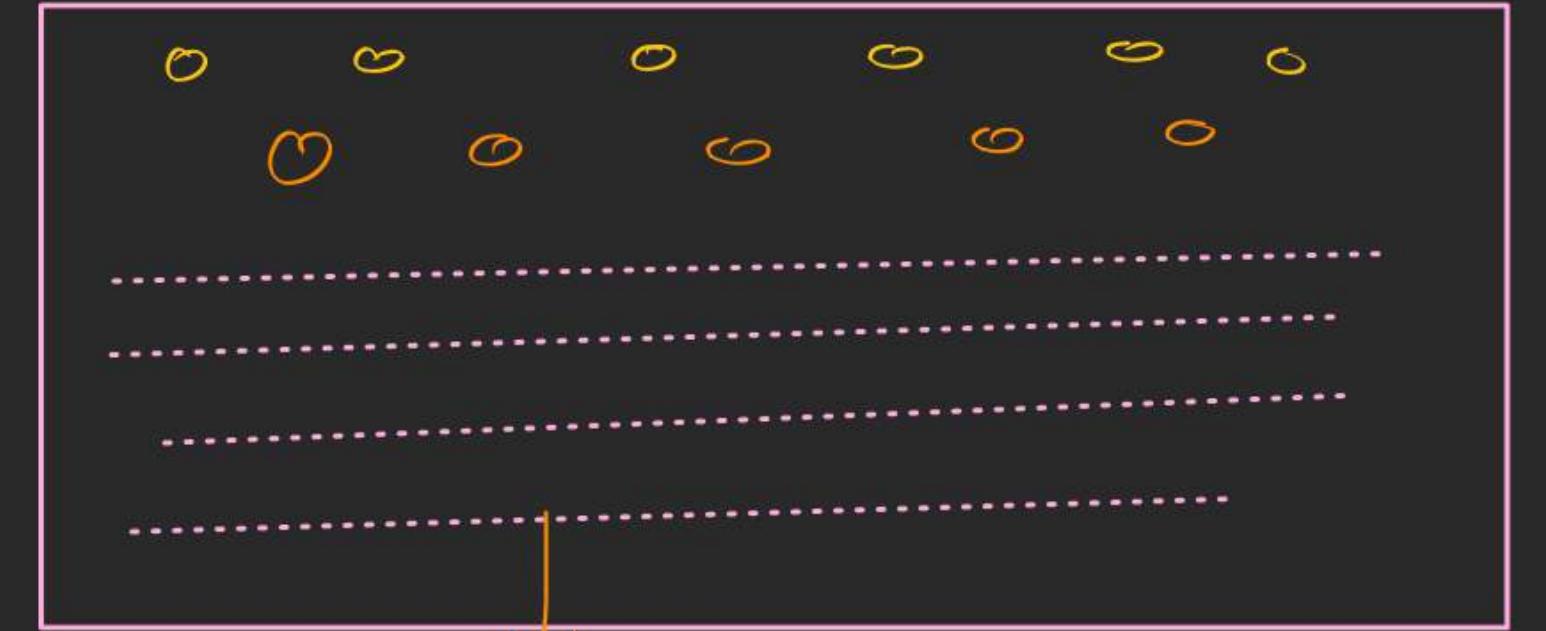
Volatile Solvent
(A)

$$P_A^o = V.P \text{ of } A \text{ in Pure form}$$



Volatile Solute
(B)

$$P_B^o = V.P \text{ of } B \text{ in pure form}$$



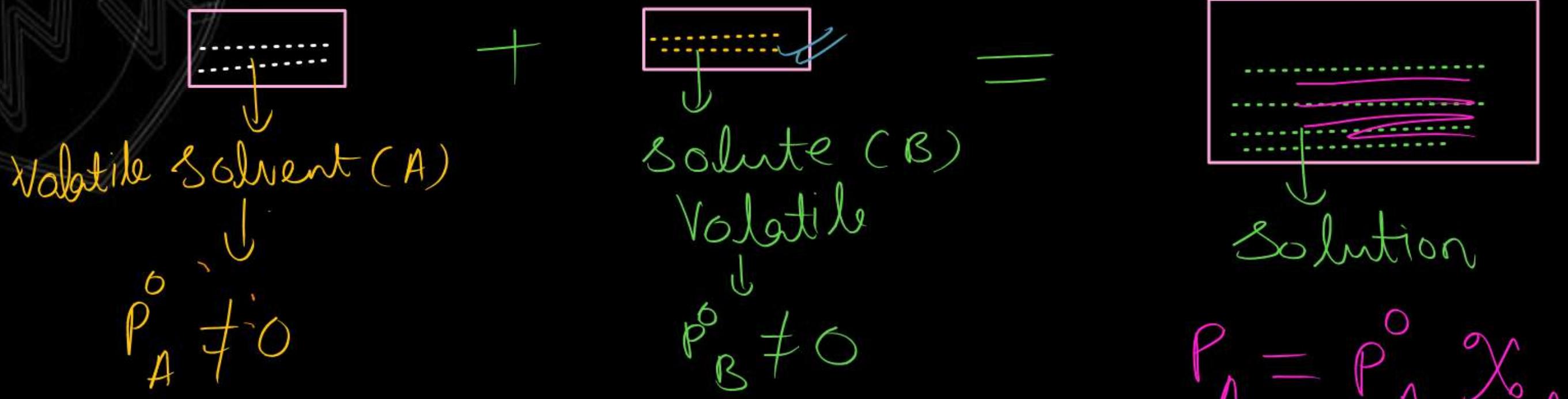
P_A = v.p. of A in
solution

P_B = v.p. of B in
solution

$$P_A = P_A^0 \chi_A$$

$$P_B = P_B^0 \chi_B$$

RAOULT'S LAW FOR VOLATILE SOLUTE



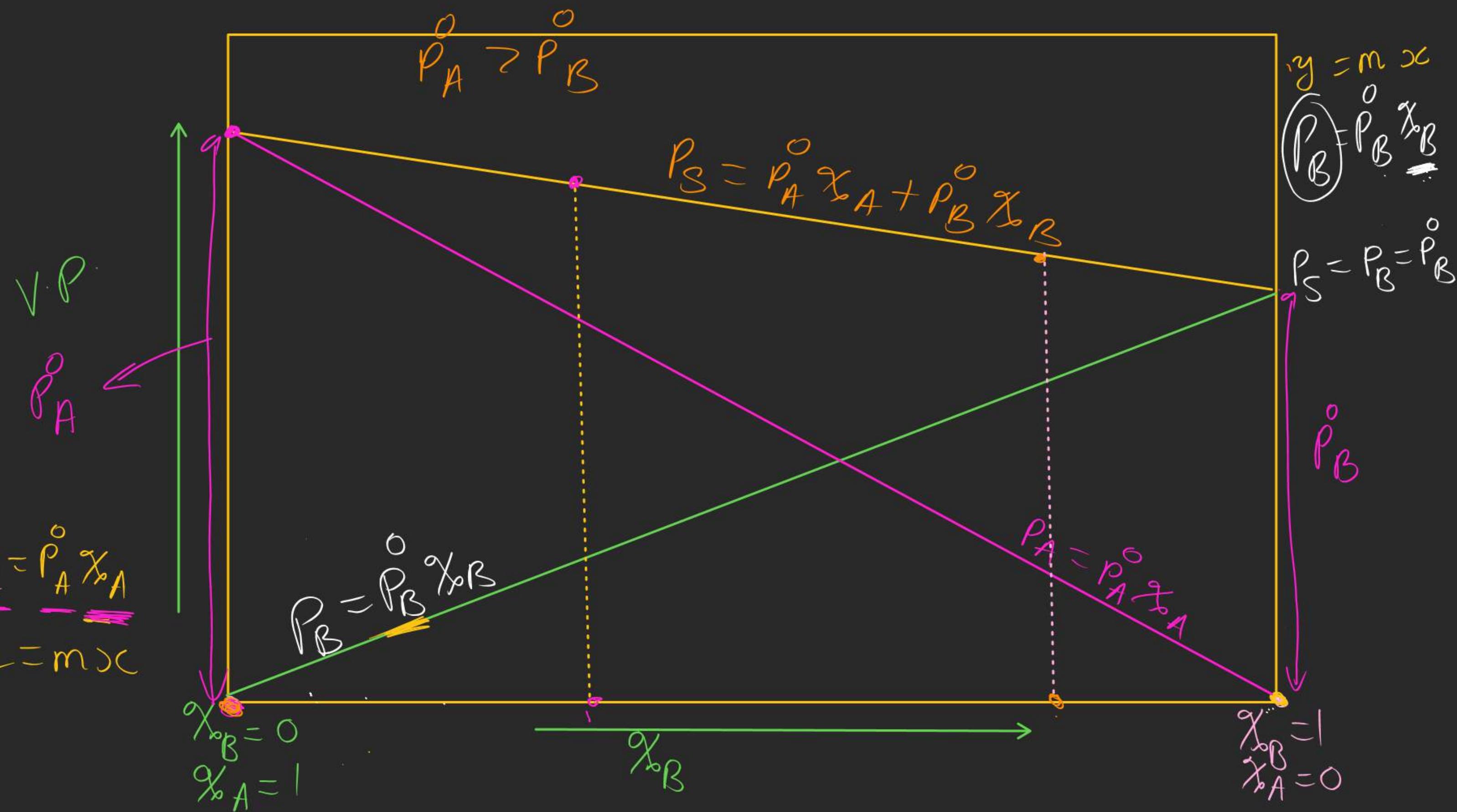
$$P_A = P_A^0 X_A$$

A box containing the equation for Raoult's Law. Inside the box, there is a blue circle with "P_S" and a downward arrow. To the right of the circle is the equation $P_S = P_A^0 X_A + P_B^0 X_B$. Below the equation is the text "V.P. of solution".

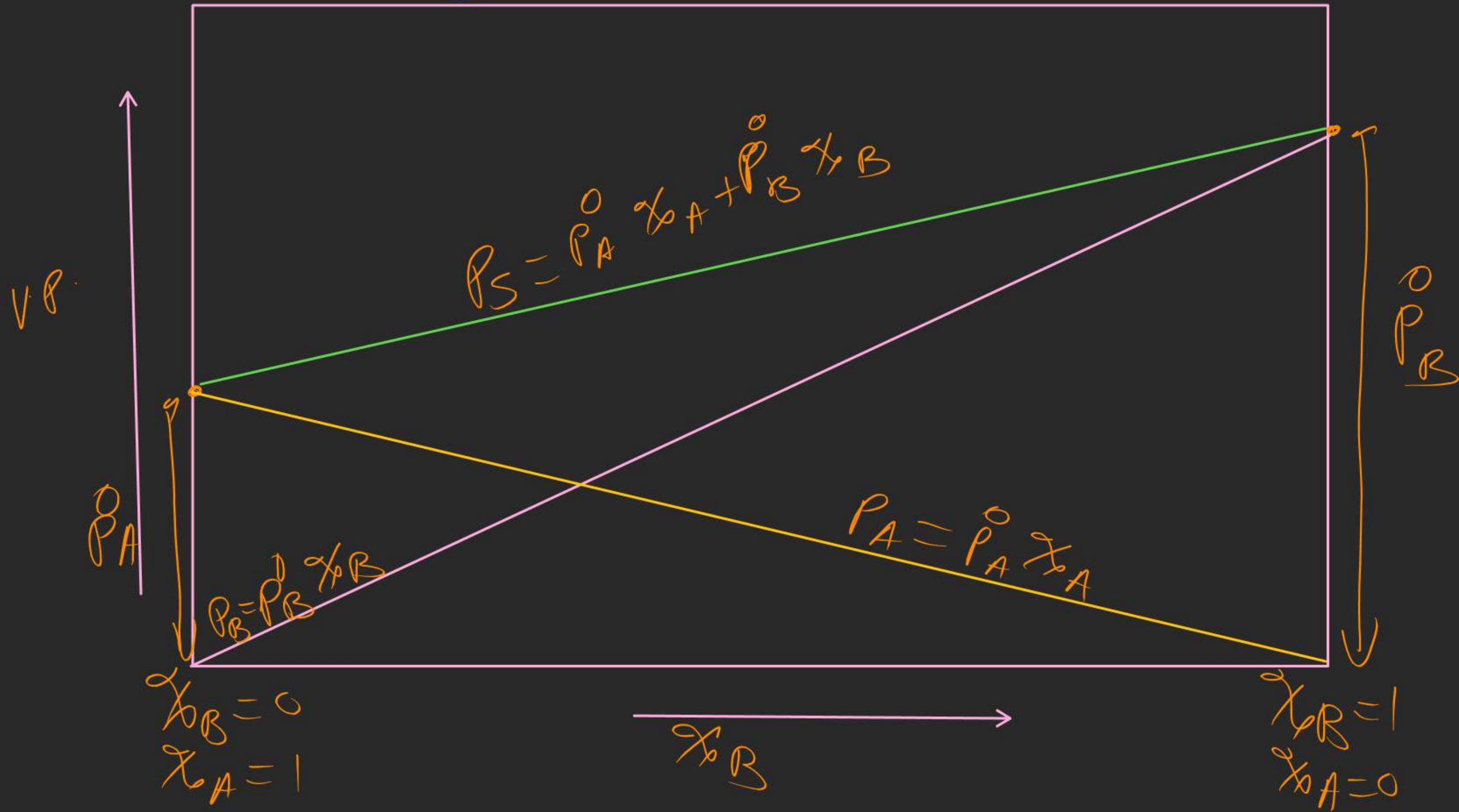
$$P_S = P_A^0 X_A + P_B^0 X_B$$

V.P. of solution

$$P_B = P_B^0 X_B$$



$$P^o_B > P^o_A$$



$$P_S = P_A^o \chi_A + P_B^o \underline{\chi_B}$$

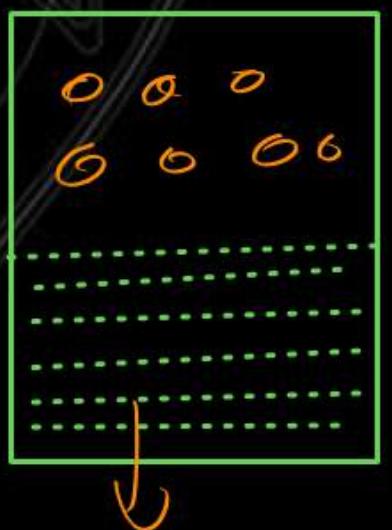
$$\chi_B = 0, \chi_A = 1$$

$$(P_S) = P_A^o$$

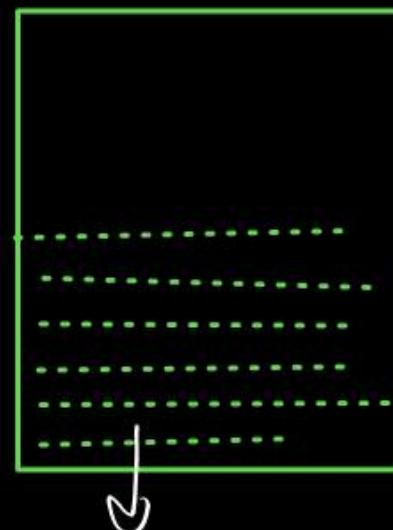
$$\chi_B = 1, \chi_A = 0$$

$$P_S = P_B^o$$

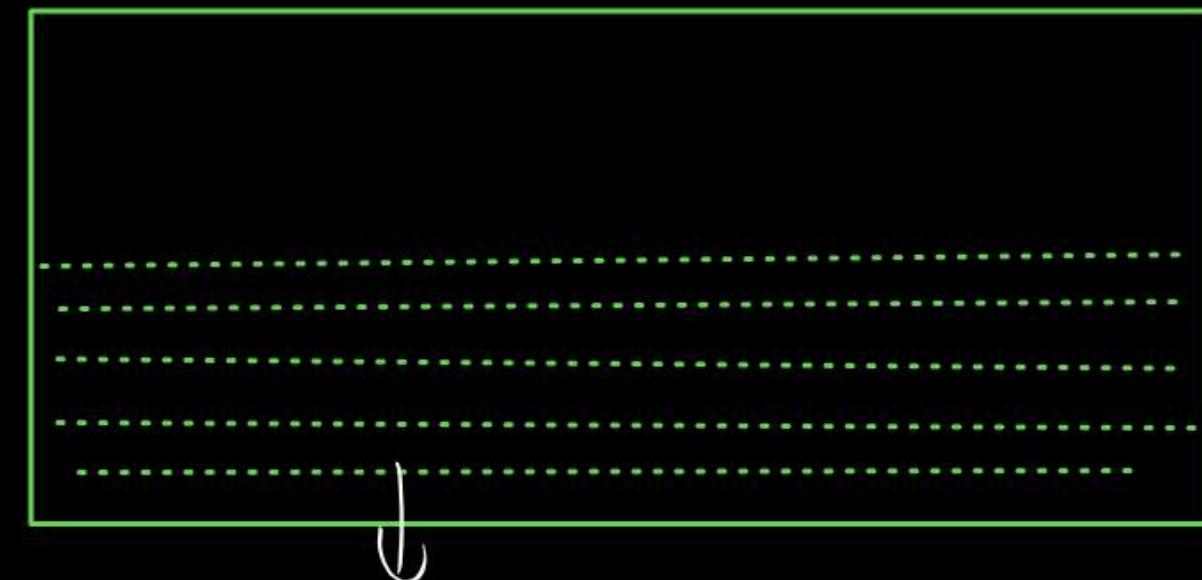
RAOULT'S LAW FOR NON-VOLATILE SOLUTE



Volatile
Solvent
 $P_A^0 + 0$



Non-Volatile
Solute
 $P_B^0 = 0$

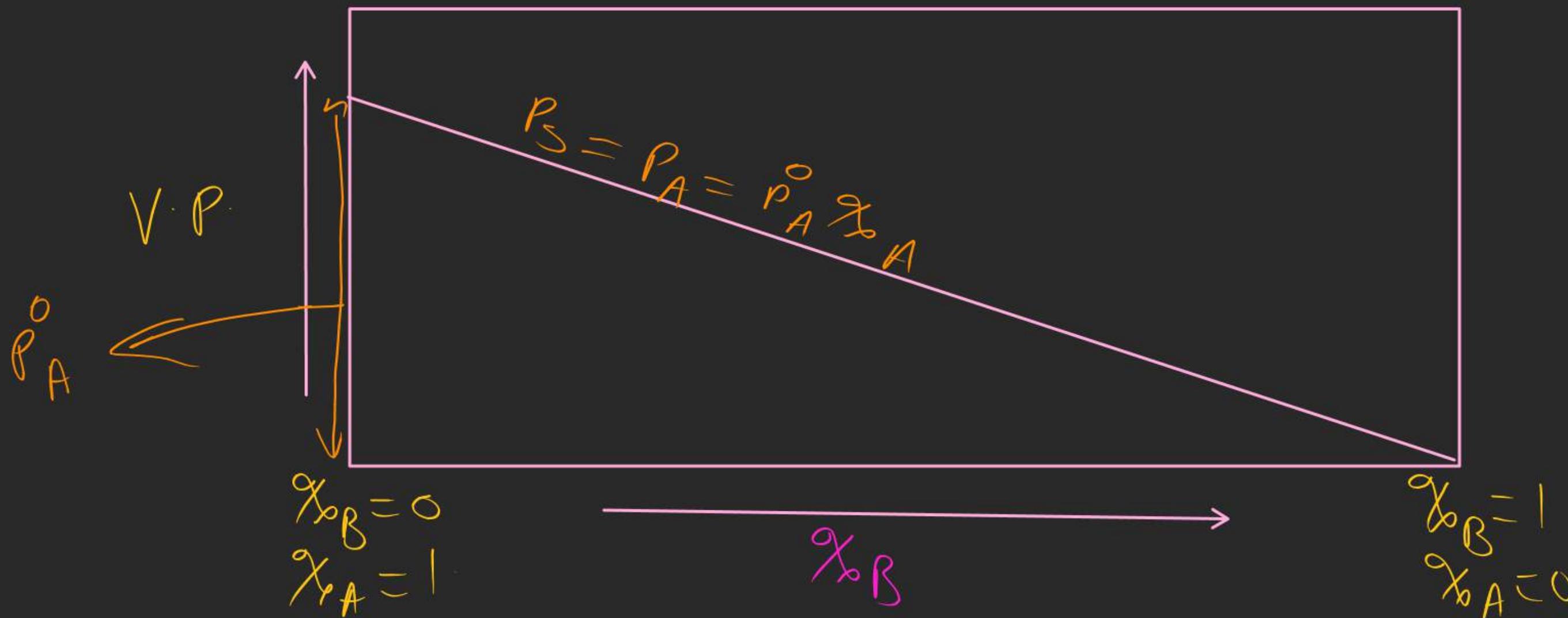


Solution

$$P_S^0 = P_A^0 \chi_A + P_B^0 \chi_B$$

$$P_S = P_A^0 \chi_A = P_A \quad (\text{as } P_B^0 = 0)$$

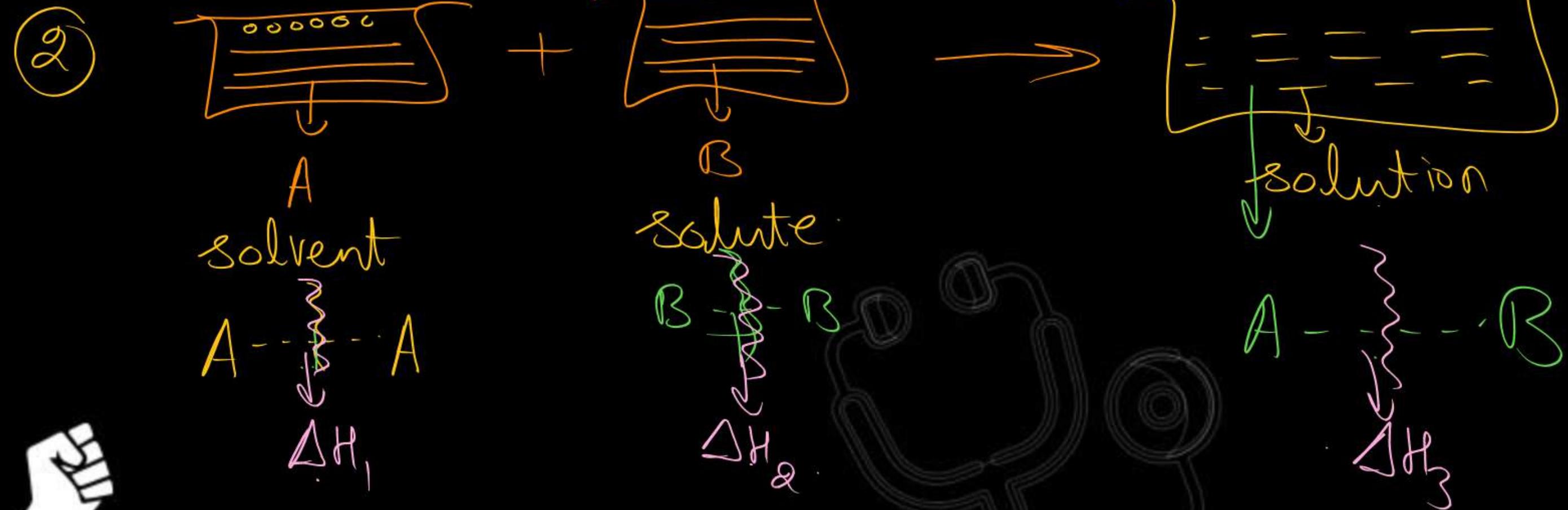
↓
Raoult's law for non-volatile solute



IDEAL SOLUTION



① Solution which obey Raoult's law at all temperature & pressure



PROPERTIES OF IDEAL SOLUTION



a

$$P_S = \underline{P_A^o x_A} + \underline{P_B^o x_B}$$

$$(x_A + x_B = 1)$$

$$P_S = P_A^o (1 - x_B) + P_B^o x_B$$

$$x_A = (1 - x_B)$$

$$P_S = \underline{(P_A^o)} - \underline{P_A^o x_B} + \underline{P_B^o x_B}$$

$$x_B = 1 - x_A$$

$$P_S = \underline{(P_B^o - P_A^o)} x_B$$

$$+ P_A^o$$

⑥ $\Delta H_{\text{mixing}} = 0$

⑦ $\Delta V_{\text{mixing}} = 0$

★⑧ $\Delta S_{\text{mixing}} = (+)\text{ve}$

★⑨ $\Delta G_{\text{mixing}} = (-)\text{ve}$

for every spontaneous
reaction

for ex - same Homologous series

@ n-Heptane + n-Octane



Benzene Toluene



MOLE FRACTION OF ANY COMPONENT IN VAPOUR PHASE

y_A = Mole fraction of A in Vapour phase.

using D.P.P (Dalton's law of Partial Pressure)

$$P_A = y_A P_T \quad (P_T = P_S)$$

$$P_A = Y_A P_S$$

$$Y_A = \frac{P_A}{P_S}$$

$$Y_A = \frac{P_A^o X_A}{P_A X_A + P_B X_B}$$

$$P_B = Y_B P_S$$

$$Y_B = \frac{P_B}{P_S}$$

$$Y_B = \frac{P_B^o X_B}{P_A X_A + P_B X_B}$$

if $\chi_A = \chi_B$ & $P_A^o > P_B^o$

$$\Rightarrow Y_A > Y_B$$

& also $Y_A > \chi_A$

$$\frac{P_S}{P_S} = 1$$

$$\chi_A + \chi_B = 1$$

$$Y_A + Y_B = 1$$

$$\frac{P_A}{P_S} + \frac{P_B}{P_S} = 1$$

$$\frac{P_A + P_B}{P_S} = 1$$

Benzene and toluene form a ideal solution and V.P. of pure benzene and toluene are 160 mm of Hg and 60 mm of Hg. Calculate partial pressure of benzene and toluene and total pressure also

- (a) Containing equal mass of both benzene and toluene → Molar mass of Benzene = 78 g
- (b) Containing equal molecules of both benzene and toluene
- (c) Containing 1 mole of benzene and 4 moles of toluene
- (d) Also calculate mole fraction of Benzene and toluene in vapour phase if equal moles of benzene and toluene mixed

A → Toluene

B → Benzene

$$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B$$

$P_B^\circ = 160 \text{ mm of Hg}$) $P_A^\circ = 60 \text{ mm of Hg}$

$$\left. \begin{array}{l} P_A = ? \\ P_B = ? \\ P_S = ? \end{array} \right\}$$

$$\text{Net mass of Benzene \& Toluene} = \frac{78 \times 92}{176} = 71.76$$

$$n_B = \frac{71.76}{78} = 0.92 \quad | \quad \chi_A = \frac{78}{78+92} = \frac{78}{176} = 0.46$$

$$n_T = \frac{71.76}{92} = 0.78 \quad | \quad \chi_B = 1 - \chi_A = 0.54$$

$$P_A = P_A^o \chi_A$$

$$P_B = P_B^o \chi_B$$

$$P_A = 60 \times 0.46$$

$$P_B = 160 \times 0.54$$

$$P_S = P_A + P_B$$

$$\begin{aligned} P_S &= 66 \times 0.46 + 160 \times 0.54 = \\ &= 27.6 + 86.4 = 114 \end{aligned}$$

b)

het molecules of Benzene & Toluene = N_A

$$\underline{n}_A = \frac{N_A}{N_A} = 1 \quad | \quad \underline{n}_B = \frac{N_A}{N_A} = 1$$

$$\underline{x}_A = \frac{\underline{n}_A}{\underline{n}_A + \underline{n}_B} = \frac{1}{2} = 0.5 \quad | \quad \underline{x}_B = 0.5$$

$$P_A = P_A^o \chi_A = 60 \times \frac{1}{2} = 30 \text{ mm of Hg}$$

$$P_B = P_B^o \chi_B = 160 \times \frac{1}{2} = 80 \text{ mm of Hg}$$

$$P_S = P_A^o \chi_A + P_B^o \chi_B$$

$$= 30 + 80 = 110 \text{ mm of Hg}$$

(C)

$$n_B = 1$$

$$n_A = 4$$

$$\chi_A = \frac{4}{5} = 0.8$$

$$\chi_B = 1 - \chi_A = 0.2$$

$$P_A = 60 \times 0.8 = 48 \text{ mm of Hg}$$

$$P_B = 160 \times 0.2 = 32 \text{ mm of Hg}$$

$$P_S = 48 + 32 = 80 \text{ mm of Hg}$$

$$\textcircled{d} \quad Y_A = \frac{P_A^0 \chi_A}{P_S} = \frac{3\phi - 3}{11\phi - 11} \quad \left| \begin{array}{l} n_A = n_B \\ \chi_A = \chi_B = \frac{1}{2} \end{array} \right.$$

$$Y_B = \frac{P_B^0 \chi_B}{P_S} = \frac{8\phi - 8}{11\phi - 11}$$

The vapour pressure of two liquids P and Q are 80 and 60 torr respectively. The total vapour pressure of solution obtained by mixing 3 moles of P and 2 moles of Q would be

[AIIMS 2012]

- (a) 140 torr
- (c) 68 torr

- (b) 20 torr
- (d) 72 torr

As

$$\begin{array}{l|l} P_A^o = 80 & n_A = 3 \\ P_B^o = 60 & n_B = 2 \\ \hline P_S = & \chi_A = \frac{3}{5} = 0.6 \\ & \chi_B = \frac{2}{5} = 0.4 \end{array}$$

$$\begin{aligned} P_S &= P_A^o \chi_A + P_B^o \chi_B \\ &= 80 \times \frac{3}{5} + 60 \times \frac{2}{5} \\ &= 48 + 24 = 72 \text{ torr} \end{aligned}$$

p_A^o and p_B^o are the vapour pressure of pure liquid components A and B respectively of an ideal binary solution. If χ_A represents the mole fraction of component A, the total pressure of the solution will be [CBSE AIPMT]

(a) $p_A^o + \chi_A (p_B^o - p_A^o)$

(c) $p_B^o + \chi_A (p_B^o - p_A^o)$

(b) $p_A^o + \chi_A (p_A^o - p_B^o)$

(d) $p_B^o + \chi_A (p_A^o - p_B^o)$

A

$$P_S = p_A^o \chi_A + p_B^o (1 - \chi_A)$$

$$P_S = \underbrace{p_A^o \chi_A}_{\text{constant}} + \underbrace{(p_B^o)}_{\text{variable}} - \underbrace{p_B^o \chi_A}_{\text{variable}}$$

$$\boxed{P_S = (p_A^o - p_B^o) \chi_A + p_B^o}$$

For an ideal solution, the correct option is

[NEET-2019]

(a) $\Delta_{\text{mix}} S = 0$ at constant T and P \times

(c) $\Delta_{\text{mix}} H = 0$ at constant T and P

(b) $\Delta_{\text{mix}} V \neq 0$ at constant T and P \times

(d) $\Delta_{\text{mix}} G = 0$ at constant T and \times

AB



Which one of the following is **incorrect** for ideal solution?

- (a) $\Delta H_{\text{mix}} = 0$ ✗
(c) $\Delta P = P_{\text{observed}} - P_{\text{calculated by Raoult's law}} = 0$ ✗

(b)

(d)

[NEET-Phase-2-2016]

$$\Delta U_{\text{mix}} = 0$$

$$\Delta G_{\text{mix}} = 0$$

$$\Delta P = P_{\text{observed}} - P_{\text{calculated by Raoult's law}} = 0$$

wrong

[AIPMT-2015]

Which one is not equal to zero for an ideal solution?

(a) $\Delta P = P_{\text{observed}} - P_{\text{Raoult}}$

(c) ΔS_{mix}

(b) ΔH_{mix}

(d) ΔV_{mix}

Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C (Given, Vapour Pressure Data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa) [NEET-2016]

- (a) Not enough information is given to make a prediction \times
- (b) ~~The vapour will contain a higher percentage of benzene~~
- (c) The vapour will contain a higher percentage of toluene
- (d) The vapour will contain equal amounts of benzene and toluene

Ans

$$n_A = n_B \Rightarrow x_A = x_B = \frac{1}{2}$$

$$y_A = ?$$

$$y_B = ?$$

Toluene Benzene

$$P_B^o = 12.8 \text{ kPa}$$

$$P_A^o = 3.85 \text{ kPa}$$

P
W

as $\rho_B^o > \rho_A^o$ ($x_A = x_B$)

$$\frac{Y_B}{J} > \frac{Y_A}{J}$$

Toluene

Benzene

At a given temperature, the vapour pressure in mm of Hg of a solution of two volatile liquids A and B is given by equation $P = 120 - 80 \chi_B$

Calculate V.P. of pure A and B at same temperature

A

$$P_S = 120 - 80 \chi_B$$

$$P_S = -80 \cancel{\chi_B} + 120$$

$$P_S = (P_A^o - P_B^o) \cancel{\chi_B} + P_A^o$$

$$P_B^o - P_A^o = -80 \Rightarrow P_B^o - 120 = -80 \Rightarrow P_B^o = 40$$

$$P_A^o = ?$$

$$P_B^o = ?$$

$$P_A^o = 120$$

Two liquids A and B form an Ideal solution at 300 K the V.P. of solution having 1 mole of A and 3 mole of B is 550 mm of Hg. At same temperature if 1 more mole of B is added to solution, V.P. of solution increases by 10 mm of Hg. Determine V.P. of A and B in pure state.

A₂

$$P_S = 550 \text{ mm of Hg}$$

$$n_A = 1$$

$$P_A^o = x \text{ mm of Hg}$$

$$n_B = 3$$

$$P_B^o = y \text{ mm of Hg}$$

$$\begin{aligned} x_A &= \frac{1}{4} \\ &= 0.25 \end{aligned}$$

$$x_B = \frac{3}{4} = 0.75$$

$$n_B' = 4$$

$$n_A' = 1$$

$$x_A' = \frac{1}{5} = 0.2$$

$$x_B' = \frac{4}{5} = 0.8$$

$$P_S' = 560 \text{ mm of Hg}$$

$$\underline{P_A^0} \underline{x_A} + \underline{P_B^0} \underline{x_B} = P_S$$

$$\underline{0.2} \times \underline{[0.25x + 0.75y = 550]}$$

$$\underline{0.25x [0.2x + 0.8y = 560]}$$

$$0.15y = 110$$

$$\pm 0.2y = \pm 140$$

$$+ 0.05y = + 30$$

$$y = \frac{30}{0.05}$$

$$y = \frac{30 \times 100}{2} = 600$$

$$x = 400$$



The V.P. of pure liquids A and B are 450 and 700 mm of Hg. Find out composition of liquid mixture if total vapour pressure is 600 mm of Hg.
 Find composition of vapour phase

$$P_A^o = 450$$

$$P_B^o = 700$$

$$\chi_A = ?$$

$$\chi_B = ?$$

$$P_S = 600$$

$$P_S = \left(P_B^o - P_A^o \right) \chi_B + P_A^o$$

$$600 = 250 \chi_B + 450$$

$$150 = 250 \chi_B$$

$$\chi_B = \frac{150}{250} = \frac{3}{5}$$



$$\chi_A = 1 - \chi_B = 1 - \frac{3}{5} = \frac{2}{5}$$

$$Y_A = \frac{P_A \chi_A}{P_S} = \frac{450 \times 0.2}{600} = \frac{90}{600} = \frac{9}{60}$$

$$Y_B = 1 - Y_A = 1 - \frac{9}{60} = \frac{51}{60}$$





thanks
for watching

